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is estimated by the German Consul General, P. Freudenberg, at about ten million pounds sterling. This disease also occurs in Java, but its ravages there have been partly offset by the introduction of a more resistant species of coffee, *Coffea liberica* from West Africa, which also yields more fruit and endures the hot Javan climate very well, even down to the coast.

Both in India and Java variegated plants are common and are used for ornamental purposes so extensively as to form a characteristic and striking feature of the garden landscape.—ERWIN F. SMITH.

MAYER, ADOLF.—*Ueber die Mosaikkrankheit des Tabaks.** <Landw. Ver. Stat., vol. XXXII. Berlin, 1886, pp. 451-467, pl. 1.

Tobacco plants in parts of Holland are subject to a variegated leaf disease. This is sometimes so serious as to take the whole crop, but ordinarily only scattered plants in the field are affected and there is no indication of infection from plant to plant, although sometimes several affected plants may be together.

The disease generally appears three to five weeks after the plants have been set out, when they are well rooted and have begun to grow vigorously. The first symptom is a geographic or mosaic coloring of the leaf surface, light and dark green, but otherwise the leaf appears sound. Soon with assistance, and a little later to the naked eye a considerable number of thickenings are visible in the green spots. These green spots grow so much more than the pale places that there are numerous irregular bendings of the leaf surface. Finally the light parts die early. The dark parts of the leaves also take on in later stages of the disease a transparent and lac-colored shade. When a single leaf is attacked all the younger leaves are sure to be, but at first only show earlier stages. The injuries caused by the disease are:

(1) Limitation of growth and a smaller harvest in consequence.

(2) Curling (wrinkling) of the leaves and unsuitability for cigar manufacture.

(3) Brittleness with the same result.

(4) Imperfect ripening and therefore incomplete (*schlechter*) burning, also injury of the aroma, so far as this can be said of any European tobacco. Once only the author found a little of the disease at Karlsruhe, in south Germany. The growers call the disease bunt, rust, and smut. The name "mosaic disease" was given by Dr. Mayer.

Dr. Mayer undertook a prolonged investigation to determine the cause of this disease. The opinions of practical men as to the cause were extremely diverse. The attention of the experiment station (Rÿksproef

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*This paper appeared some years ago, but seems to have been generally overlooked by botanists, owing to its place of publication. The subject is one of much interest and it is believed that readers of the Journal will be glad of an abstract. A recent letter from Dr. Mayer states that no microorganism has yet been isolated from the affected plants.

Station zu Wageningen) was first called to this disease in 1879 by the transmission of healthy and diseased leaves, with the inquiry: "Was mag der Grund sein, dass in den letzten Jahren die Tabakspflanze so sehr leidet durch den sogenannten Rost?"

A comparative chemical analysis was first made of healthy and diseased leaves. This showed no lack of N, K, or Ca in the diseased leaves. In tobacco culture there is under ordinary conditions no lack of P_2O_5, because the plants make only moderate demands on this substance, and in the culture methods here in vogue an excess is given to the soil. Analyses of the earth from tobacco-sick fields also showed that there was no deficiency of plant food. Tobacco is known to be very greedy for lime, and consequently a sick earth and one not subject to the disease were compared. The lime content was small in both, but not essentially unlike. These determinations, combined with the results reached by experienced growers, seemed to show that the disease was not due to defective nutrition.

A search was then made for nematodes in healthy and sick earth. Some were found, but only such as live in humus, and no connection between them and the disease was established.

Plants were grown in specially constructed seed beds, with varying temperatures, degrees of moisture, and amounts of nitrogen, and their behavior after transplanting closely watched. They all developed normally, remained healthy, and were very fine at the end of summer, but not so large as those grown in the regular way and set out somewhat earlier. The plants were also set out with twisted and injured roots, but this was harmless. All grew into fine plants.

Plants were also grown at high temperatures in moist air and suddenly transported to the field. No disease resulted.

The hypothesis that crowding and etiolation in the seed bed might be a cause of the trouble was also tested and found wanting. In 1881 the disease was common, and the author had good opportunity to study it near Wageningen and Rhenen. Here for the first time it was observed that foreign kinds of tobacco escaped the disease entirely, while the disease was not completely absent from any of the sorts commonly grown.

In 1882 various experiments were made to determine whether self or cross-fertilization played any part. Plants from the seeds of diseased plants were also grown. None of these experiments had any influence on the disease. As usual it appeared on land subject to it and did not appear in other places. All these results seemed to indicate a disease due to parasites.

The tissues were searched zealously for fungi, animal parasites, etc., not only by the author, but also by several of his friends. At first no results were obtained. Only one authority thought he found a mycelium in the diseased parts of the leaves, "die sich zu einer Septoria oder Phoma entwickeln dürften." It was at this time Dr. Mayer discovered that the disease could be induced in healthy plants by inoculating them with the expressed juice of diseased plants. By rubbing up a plainly diseased leaf in a few drops of water, taking up a little of this thick, green emulsion in a glass tube drawn out to capillary size, and sticking it into the thick midrib of an old leaf so that it remained without reaching through to the back side, sound plants became badly diseased in nine cases out of ten. The period between the inoculation and the first doubtful symptoms was quite regularly ten to eleven days. After this period the disease appeared without failure in all the younger leaves, i. e., those undeveloped at time of inoculation, and on the small shoots which developed in the axils of the diseased leaves. All the younger parts of the plants were diseased, exclusive possibly of the flowers, and all the older parts healthy.

It is self-evident that the disease is more severe in proportion to the youngness of the plant at the time of inoculation. It is much less dependent apparently on the quantity of inoculated substance (*Impfstoffs*). It is only necessary to be careful that the substance is really taken up by the plant, and this is best brought about by using a thin fluid and infecting slightly wilted plants.

After this discovery organized bodies were sought in the sap of the diseased plants with new zeal, but owing to the numerous almost colorless granules normally present in the juice no definite results were obtained. Some of these granules were not unlike red blood corpuscles, but more half-moon shape, while others were smaller. The sap was also rich in small tetrahedral bodies, which slowly disappeared in HCl, and which were probably calcium oxalate. The bodies in the sap appeared, even with the highest powers, of such indefinite form that they could not be identified with any certainty as organized bodies.

Later Dr. Mayer endeavored to isolate the supposed organisms by Koch's and other methods, and demonstrated bacteria in many cases. But none of these, when used for inoculation, caused the disease. He also inoculated sound tobacco with various bacteria, dung solutions, extract from tobacco, sick earth, etc., but without result.

The question now arose whether the disease was due to an organized or a chemical ferment. A chemical ferment seemed improbable. This sort rarely causes a disease, and it is unheard of that an enzyme multiplies from itself. An organized ferment might be a fungus or a bacterium. To determine these points the following experiments were undertaken:

The infectious fluids were passed through ordinary filter paper and the filtrate used for a large number of additional inoculations. Result: The filtered sap worked almost as well as the unfiltered. The per cent of diseased plants was only a little less. Either the disease was due to chemical substances or else to organized bodies small enough to pass through the pores of the paper. A clear filtrate was finally obtained by using a double filter, and fluid passed through this possessed no infective power. Evidently the cause of the disease was filtered out and could not be a chemical ferment, for it is opposed to all known peculiarities of enzymes to be filtered out of solutions. The common method for the concentration of an enzyme, i. e., precipitation with not too strong alcohol from the crude juice and re-solution in water, was tried. This led to no substance which had infective power.

Inoculations with heated sap led to the following results: Persistent warming at 60° did not perceptibly alter the infectious power; at 65° to 75° it was weakened. Heating the sap at 80° for several hours killed the infective power. These experiments show that the infective substance satisfies the requirements of an organized ferment, and indicate that the infective body must be searched for among the small organized bodies. Fungi are much too large to pass through filter paper, and if the disease was due to these it would seem that they must assume at some stage some more easily visible form.

The following is a rather literal rendering of the author's conclusions:

(1) The "mosaic disease" of tobacco is a bacterial disease, the infective organism of which has not yet been isolated so as to know its form and mode of life.

(2) The infective power of the disease from plant to plant under the artificial conditions of sap mixture has been established with certainty. Under natural conditions there is no plain infection from plant to plant. The seeds of diseased plants can produce sound plants.

(3) The cause of the disease must be sought in the earth of the tobacco fields and the hotbeds, for particular fields, especially those in which tobacco follows tobacco, are most exposed to the disease. A case of transportation of the disease with earth, however, was not established.

Rotation of crops is advised, also the removal of the diseased plants, and after harvest all remnants of the crop.—ERWIN F. SMITH.

MOELLER, H.—*Entgegnung gegen Frank, betreffend den angeblichen Dimorphismus der Wurzelknöllchen der Erbse.* <Ber. d. Deut. Bot. Ges., Bd. x, Nov. 24, 1892, pp. 568-570.

In a recently published note upon root tubercles, Frank states that those of the pea show two forms that differ externally, but have the same internal structure, and furthermore that the content is different, being albumen bacteroids in the one, and amylodextrin bacteroids in the other.

The author of this paper proved some time ago that these tubercles do not contain amylodextrin, but a waxy substance, and this fact made him doubt the correctness of Frank's observations. He has also studied the exterior form of such tubercles and states that vigorous specimens of pea show a considerable variety of such tubercles, but without any distinction of two special forms. An examination of their contents gave only albumen bacteroids. These investigations were